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Myxomycetes of Sonora (Mexico) 6. Central plains of the Sonoran Desert

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Abstract — Myxomycetes from 10 localities in the central plains of the Sonoran desert were studied using the moist chamber culture technique. Thirty-three species have been identified, of which five (*Comatricha mirabilis, Cribraria confusa, Didymium eremophilum, Perichaena luteola,* and *P. stipitata*) represent new records for Sonora, and *Comatricha mirabilis* is cited for the first time from Mexico. Light and scanning electron microphotographs illustrate the most diagnostic characters of these species, which are rare or scarcely mentioned in the literature.

Key words — *Amoebozoa,* chorology, myxobiota, slime moulds, taxonomy

Introduction

The Sonoran desert, which lies in northwestern Mexico and the southwestern United States, covers a 260,000-km2 area, with the largest portion occurring in Sonora state (Mexico) and the rest in southwestern Arizona and southeastern California (United States). This is the warmest and the most arid North American desert due to its low elevation (≤600 m) and 22–24 °C average annual temperature. The bi-seasonal (winter and summer) rainfall averages 200–400 mm per year (Hernández 2006).

The desert vegetation is characterized by trees and shrubs, including *Parkinsonia florida* (A. Gray) S. Watson, *Olneya tesota* A. Gray, *Prosopis glandulosa* Torr., *Fouquieria macdougalii* Nash, and *Bursera* spp. The majority of the cacti are large, with *Carnegiea gigantea* (Engelm.) Britton & Rose the

Table 1. Studied Sonoran localities and types of vegetation

Locality	Latitude N	Longitude W	Altitude	Vegetation
Town of Benjamin Hill				
1. Las Animas	30°12′37.95″	111°18′55.04″	770 m	MDS
Town of Opodepe				
2. Tuape	30°02′52.89″	111°00′22.05″	670 m	M
Town of Guaymas				
3. Cañón de Nacapule	27°59′08.54″	111°02′06.40″	81 m	SC
4. El Tigre	28°06′31.14″	111°01′21.11″	139 m	SC
5. El Apache	28°19′25.33″	111°14′27.74″	43 m	M
6. Maytorena	28°13′32.49″	110°48′50.28″	40 m	SC
Town of Carbó				
7. San Luis	29°33′42.38″	111°04′52.79″	458 m	MDS
Town of Hermosillo				
8. La Primavera	28°48′06.37″	111°09′09.62″	167 m	MDS
9. La Pintada	28°39′56.35″	110°57′15.64″	233 m	SC
10. El Papalote	29°12′56.14″	111°02′39.43″	348 m	M

Types of vegetation: MDS = microphyllous desert scrub; SC = sarcocaule scrub; M = mezquital

most representative (Hernández 2006). Myxomycetes can develop in arid environments due to decomposition of and water retained by succulent plants such as *Opuntia* spp. These provide an excellent microhabitat with enough moisture for optimal development. Although the Sonoran desert has a high level of biological diversity, here have been only a few studies of its myxobiota.

The Sonoran desert records of Evenson (1961) and Blackwell & Gilbertson (1980a,b; 1984) were obtained mainly in Arizona (U.S.A.) in the United States. Although there have been various diverse studies of the myxobiota in Sonora (Mexico), only twenty-seven reports are known for the biosphere reserve El Pinacate and Gran Desierto de Altar (Esqueda et al. 2013, Moreno et al. 2004); most studies have been centered in pine–oak forests and lowland areas (Pérez-Silva et al. 2001; Moreno et al. 2006; Lizárraga et al. 2007, 2008a,b).

The catalogue of myxomycetes for Sonora state (Moreno et al. 2007) has been increased from 77 species to 108 species by Lizárraga et al. (2007, 2008a,b) and Esqueda et al. (2013). The present contribution brings the total number to 113.

Materials & methods

Four surveys were conducted in 2009, one each season of the year, in 10 localities of the central plains of the Sonoran desert (Table 1). Specimens were gathered or cultured in moist chamber cultures. Permanent slides were prepared in Hoyer's liquid for microscopic study. Collections have been deposited in the collection of fungi of the

Universidad Estatal de Sonora, Hermosillo, Sonora, México (UES), with a small part in the herbarium of the Universidad de Alcalá, Alcalá de Henares, Madrid, Spain (AH). The spore ornamentation was examined under SEM using the material deposited in AH. Collector names are abbreviated as follows: AG = A. Gutiérrez; ML = M. Lizárraga; CS = C. Salazar; and AS = A. Sánchez. New species records for Sonora are marked with a single asterisk, and the species recorded as new for Mexico is marked with two asterisks.

Taxonomy

Arcyria cinerea (Bull.) Pers.

Studied material: **MEXICO. Sonora: Loc. 4**, on *Forchhammeria watsonii* Rose, leg. ML, CS, AS & AG, 19-VIII-2009, obtained from moist chamber, 30-IX-2009 (UES 8539); obtained from moist chamber, 9-X-2009 (UES 8541).

Comments— Previously cited for Sonora by Lizárraga et al. (2007, 2008b).

Arcyria denudata (L.) Wettst.

Studied material: **MEXICO. Sonora: Loc. 1**, on decomposing wood, leg. AG & AS, 22-V-2009, obtained from moist chamber, 11-VI-2009 (UES 8106).

Comments—Previously recorded for Sonora by Pérez-Silva et al. (2001), and Lizárraga et al. (2008a,b).

Badhamia gracilis (T. Macbr.) T. Macbr.

Studied material: **MEXICO. Sonora: Loc. 1**, on *Cylindropuntia* sp., leg. AS & AG, 9-III-2009, obtained from moist chamber, 20-IV-2009 (UES 7858); **Loc. 2**, on *Opuntia* sp., leg. AS & AG, 14-III-2009, obtained from moist chamber, 15-IV-2009 (UES 7854); **Loc. 3**, on *Stenocereus thurberi* (Engelm.) Buxb., leg. AS & AG, 26-V-2009, obtained from moist chamber, 30-VI-2009 (UES 8206); **Loc. 4**, on *Lophocereus schottii* (Engelm.) Britton & Rose, leg. CS, AS & AG, 7-XI-2009, obtained from moist chamber, 4-XII-2009 (UES 8660); **Loc. 5**, on *Parkinsonia* sp., obtained from moist chamber, 20-IV-2009 (UES 7856); **Loc. 6**, on *Cylindropuntia versicolor* (Engelm.) F.M. Knuth, leg. AG & AS, 12-III-2009, obtained from moist chamber, 6-IV-2009 (UES 7845); **Loc. 7**, on *Stenocereus thurberi*, obtained from moist chamber, 14-IV-2009 (UES 7962); **Loc. 8**, on *Lophocereus schottii,* leg. AS & AG, 14-III-2009, obtained from moist chamber, 14-IV-2009 (UES 7847); **Loc. 9**, on *Cylindropuntia arbuscula* (Engelm.) F.M. Knuth, leg. AG & AS 26-V-2009, obtained from moist chamber, 11-VI-2009 (UES 8110); **Loc. 10**, on *Parkinsonia* sp., leg. AS & AG, 12-III-2009, obtained from moist chamber, 20-IV-2009 (UES 7860).

Comments—We follow the taxonomy of Moreno & Oltra (2010), who regarded *Badhamia melanospora* Speg. as separate from *B. gracilis*. The two species differ mainly in spore morphology, with the spores >15–17 µm diam., polyhedral, and densely warty in *B. melanospora* and <12–14 µm diam, polyhedral, and with scattered warts with intervening spaces in *B. gracilis*. Both species fruit mainly on succulent plants (Castillo et al. 1996). Some studied collections were mistakenly identified as *B. melanospora* by Moreno et al. (2006) and Esqueda et al. (2013).

Badhamia spinispora (Eliasson & N. Lundq.) H.W. Keller & Schokn. Figs 1, 5–6

Fructifications sessile, subglobose to short plasmodiocarps, white to grey, growing grouped together. Sporotheca 0.2–1 × 0.2–0.5 mm. Peridium double, calcareous, with irregular dehiscence. Hypothallus inconspicuous. Pseudocolumella irregular, calcareous. Capillitium scarce and joined by strands consisting of irregular calcareous nodules. Spores (9–)10–12 × 13–15 µm, globose to subglobose, black in mass, violaceous with a paler area under LM, ornamented with large spines. SEM shows that the spore ornamentation is formed by irregularly scattered or grouped <0.5 µm high warts.

Studied material: **MEXICO. Sonora: Loc. 9,** over hare manure, leg. AG & AS, 26-V-2009; obtained from moist chamber, 30-VI-2009 (UES 8116, AH 42974).

Comments—This species is characterized by its generally coprophilous habitat (although it does occasionally grow on tree bark), cespitose habit, capillitium that varies from physaroid to badhamioid, and spores that are dark in mass, spiny, and with a paler area. A study of *B. spinispora, Physarum apiculosporum* Härk., and *Badhamia verrucospora* G. Moreno & al. was published by Moreno et al. (2011).

Cited from Sonora by Esqueda et al. (2012, 2013).

Comatricha elegans (Racib.) G. Lister

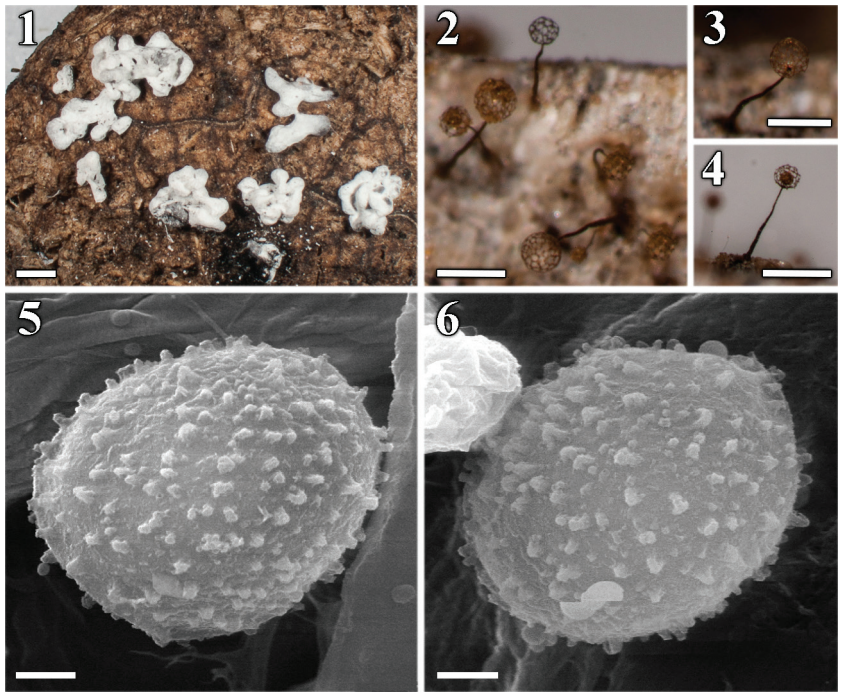
Studied material: **MEXICO. Sonora: Loc. 1**, on *Olneya tesota*, leg. AG & AS, 22-V-2009, obtained from moist chamber, 3-VI-2009 (UES 8120); **Loc. 7**, leg. ML, CS, AS & AG, 17-VIII-2009, obtained from moist chamber, 7-IX-2009 (UES 8563); **Loc. 9,** 20-VIII-2009, obtained from moist chamber, 9-IX-2009 (UES 8621); **Loc. 10**, decomposing wood, 21-V-2009, obtained from moist chamber, 11-VI-2009 (UES 8122).

Comments—Lizárraga et al. (2005) published a study (including SEM photomicrographs) of *C. elegans* from Chihuahua.

Previously recorded from Sonora by Lizárraga et al. (2007, 2008a).

*****Comatricha mirabilis*** R.K. Benj. & Poitras Figs 7–12

Fructifications stipitate, 0.7–0.9 mm tall. Sporotheca subglobose to subcylindrical, 0.4–0.6 mm diam. Peridium fleeting and persistent at the base, resembling a necklace. Stipe short, dark, 0.3–0.6 mm high. Hypothallus membranous, hyaline, as common in *Comatricha.* Columella crossing the sporotheca and forking into several branches at the apex. Capillitium parallel along the columella, dark brown with free ends, dichotomous, widened and forked at the tips that protrude at the periphery of the sporotheca. Spores dark brown in mass, 9–12 µm diam., globose to subglobose, reticulate, with walls 1–2 µm high. SEM observation reveals that the spore is reticulate and the high banded reticulum has entire and unperforated walls.



Figures 1–6. ***Badhamia spinispora*** (AH 42974): 1. Plasmodiocarps. 5–6. Spores (SEM). ***Cribraria confusa*** (AH 42976): 2–4. Sporocarps. Bars: 1 = 1 mm; 2–4 = 0.5 mm; 5–6 = 2 µm.

Studied material: **MEXICO. Sonora: Loc. 4**, on bark of *Forchhammeria watsonii*, leg. AG & AS, 27-V-2009, obtained from moist chamber, 30-VI-2009 (UES 8129, AH 42975).

Comments—*Comatricha mirabilis* is characterized by its capillitium that extends parallel along the columella without forming a network with bifurcated ends that protrude from the sporotheca and fully reticulate globose spores. It was described growing over goat manure in USA in a moist chamber (Benjamin & Poitras 1950). Later, Mandell & Blackwell (2008) gathered abundant material from tree barks of *Tamarix arabica*, *Prosopis juliflora*, *Phoenix dactylifera,* and *Cordia myxa* from a Bahrain desert in the Kingdom of Bahrain archipelago near Saudi Arabia, which they developed in a moist chamber. Andrade-Bezerra et al. (2008) described material developed on Brazilian cottontail (*Sylvilagus brasiliensis* L.) dung in a moist chamber, Poulain et al. (2011) gathered it from France on wood debris, and Schnittler et al. (2013) identified the species from arid areas in China. We obtained three sporocarps on *Forchhammeria watsonii* bark in a moist chamber. This is the first record for Mexico.

Comatricha tenerrima (M.A. Curtis) G. Lister

Studied material: **MEXICO. Sonora: Loc. 1**, on *Olneya tesota*, leg. AS & AG, 22-V-2009, obtained from moist chamber, 15-VI-2009 (UES 8124); **Loc. 9**, on decomposing wood, leg. CS, AS & AG, 6-XI-2009, obtained from moist chamber, 11-XII-2009 (UES 8685); **Loc. 10**, on decomposing wood, leg. AG & AS, 21-V-2009, obtained from moist chamber, 6-VI-2009 (UES 8130).

Comments— Lizárraga et al. (2007) published a description with SEM micrographs of *C. tenerrima* from Sonora. It has also been cited from other natural protected areas in Sonora (Lizárraga et al. 2008a,b; Esqueda et al. 2013).

****Cribraria confusa*** Nann.-Bremek. & Y. Yamam. Figs. 2–4

Fructifications small (0.3–0.9 mm high), stipitate. Sporotheca globose to subglobose, 0.1–0.2 mm diam. Stipe 0.2–0.7 mm long, dark brown, with debris. Peridium evanescent, forming a small discoid calyculus at the base beneath an open network of irregular flattened nodules covered by dictydine granules. Hypothallus membranous. Spores 7–8 µm diam., yellow in mass, light yellow under LM, globose, with a warty ornamentation.

Studied material: **MEXICO. Sonora: Loc. 3**, on palm fibers, leg. ML, CS, AS & AG, 19-VIII-2009, obtained from moist chamber, 5-IX-2009 (UES 8570); obtained from moist chamber, 7-IX-2009 (UES 8759, AH 42976 with *Arcyria cinerea* and *Paradiacheopsis* sp.); on *Guaiacum coulteri* A. Gray, obtained from moist chamber, 3-X-2009 (UES 8571).

Comments—*Cribraria confusa* has been recorded only from Chihuahua on decomposing wood of *Pinus* sp. by Lizárraga et al. (2003), who presented LM and SEM micrographs.

Cribraria violacea Rex

Studied material: **MEXICO. Sonora: Loc. 10**, on palm fibers, leg. AG, 21-V-2009, obtained from moist chamber, 15-VI-2009 (UES 8135).

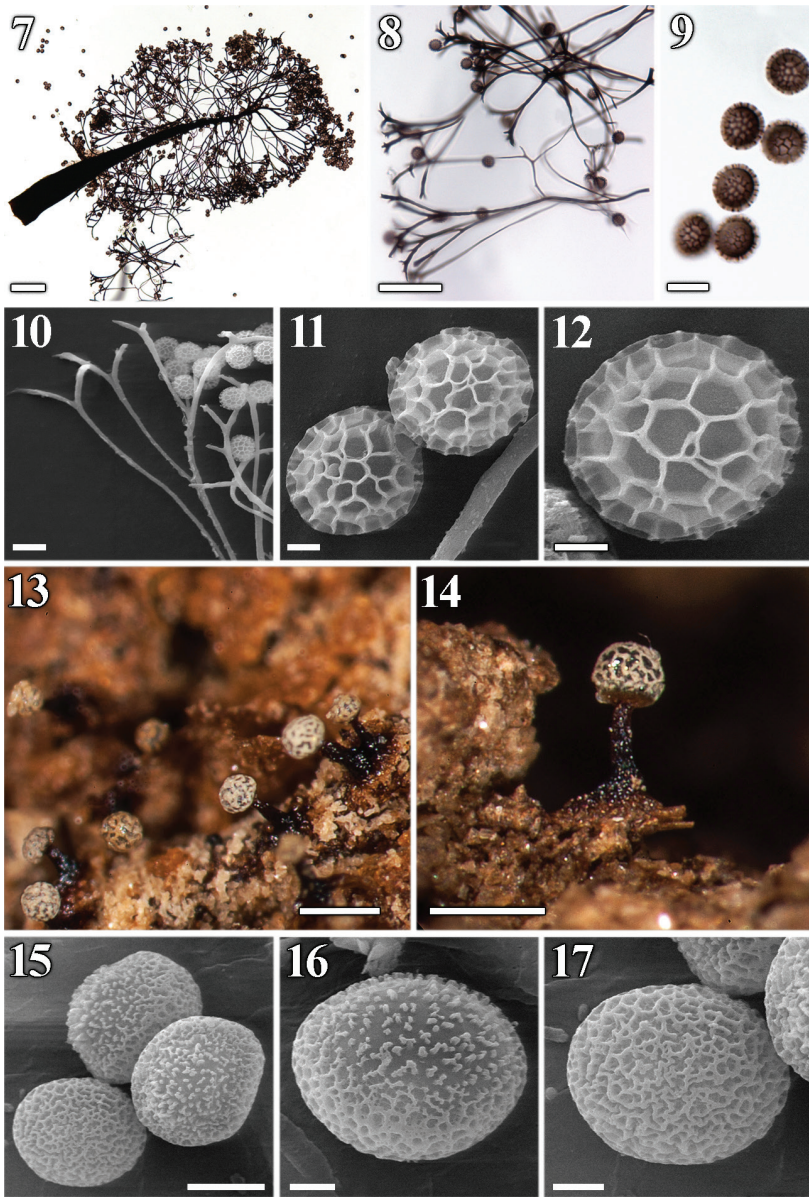
Comments— Moreno et al. (2001) published an SEM study of the spore ornamentation on material from Baja California.

Previously cited from Sonora by Moreno et al. (2006) and Lizárraga et al. (2008b).

Dictydiaethalium plumbeum (Schumach.) Rostaf.

Studied material: **MEXICO. Sonora: Loc. 1**, on decomposing wood, leg. ML, CS, AS & AG, 17-VIII-2009, obtained from moist chamber, 9-IX-2009 (UES 8572); **Loc. 5**, leg. AG & AS, 14-III-2009, obtained from moist chambers, 1-V-2009 (UES 7880).

Comments—Previously cited from Sonora by Moreno et al. (2006) and Lizárraga et al. (2008b).



Figures 7–17. ***Comatricha mirabilis*** (AH 42975): 7. Sporocarp. 8. Capillitium. 9. Spores. 10. Capillitium endings (detail, SEM). 11–12. Spores by SEM. ***Didymium eremophilum*** (AH 42977): 13. Sporocarps. 14. Sporocarp (detail). 15–17. Variability of spore ornamentation (SEM). Bars: 7 = 0.1 mm; 8 = 50 µm; 9 = 10 µm; 13–14 = 0.5 mm; 15 = 5 µm; 16–17 = 2 µm.

Didymium dubium Rostaf.

Studied material: **MEXICO. Sonora: Loc. 1**, on *Olneya tesota*, leg. AS & AG, 9-III-2009, obtained from moist chamber, 20-IV-2009 (UES 7888); **Loc. 2**, on *Prosopis glandulosa*, leg. ML, CS, AS & AG, 19-VIII-2009, obtained from moist chamber, 9-IX-2009 (UES 8755); **Loc. 5**, on *Prosopis glandulosa,* leg. AS & AG, 14-III-2009, obtained from moist chamber, 9-IV-2009 (UES 7886); **Loc. 6**, on *Prosopis glandulosa,* leg. AG & AS 12-III-2009, obtained from moist chamber, 25-IV-2009 (UES 7889); **Loc. 8**, on *Cylindropuntia* sp., leg. AG & AS, 14-III-2009, obtained from moist chamber, 14-IV-2009 (UES 7882); **Loc. 9**, on *Cylindropuntia arbuscula,* leg. CS, AS & AG, 6-XI-2009, obtained from moist chamber, 26-XI-2009 (UES 8692).

Comments—Moreno et al. (2001) published a SEM study of the spore ornamentation. Previously cited from Sonora by Moreno et al. (2006).

****Didymium eremophilum*** M. Blackw. & Gilb. Figs 13–17

Fructifications stipitate, gregarious, 0.2–0.9 mm tall. Sporotheca globose to subglobose, 0.1–0.3 mm diam., whitish with lighter zones, with a dark disc at the base. Stipe robust, 0.1–0.5 mm tall, reddish-brown to darkish brown, wider and darker at the base. Hypothallus membranous, discoid, concolorous with stipe. Peridium double, with the outer membrane formed by calcareous crosshairs, the inner membranous with iridescent blue tones. Capillitium and columella absent. Spores globose to subglobose, black in mass, violaceous by LM, 9–10 µm diam., with a reticulate hemisphere and the opposite warty (as confirmed by SEM; see Moreno & Mitchell 2013).

Studied material: **MEXICO. Sonora: Loc. 4**, leg. CS, AS & AG, 7-IX-2009, obtained from moist chamber, 4-XII-2009 (UES 8698); **Loc. 8**, on *Lophocereus schottii*, leg. AG & AS, 21-V-2009, obtained from moist chamber, 11-VI-2009 (UES 8141, AH 42977); obtained from moist chamber, 15-VI-2009 (UES 8142); obtained from moist chamber, 19-VI-2009 (UES 8143); obtained from moist chamber, 22-VI-2009 (UES 8144); obtained from moist chamber, 30-VI-2009 (UES 8145); leg. CS, AS & AG, 6-XI-2009, obtained from moist chamber, 30-XI-2009 (UES 8699); obtained from moist chamber, 11-XII-2009 (UES 8700); obtained from moist chamber, 12-XII-2009 (UES 8701); obtained from moist chamber, 12-XII-2009 (UES 8702); **Loc. 9**, on cactus remains, leg. AG & AS, 26-V-2009, obtained from moist chamber, 15-VI-2009 (UES 8146).

Comments—*Didymium eremophilum* is a succulenticolous species adapted to arid environments (Blackwell & Gilbertson 1980b), characterized by its small size, stipitate sporocarps, crystalline lime, lack of capillitium, partly reticulate verrucose spores, and succulenticolous habitat (Moreno & Mitchell 2013).

Didymium eremophilum specimens, very difficult to find due to their small size, have thus far been found only from moist chamber. Previously recorded in Mexico only from Puebla (Estrada-Torres et al. 2009), our study provides a first record for the Sonoran mycobiota.

Didymium squamulosum (Alb. & Schwein.) Fr.

Studied material: **MEXICO. Sonora: Loc. 4**, on deer manure, leg. AG & AS 12-III-2009, obtained from moist chamber, 1-V-2009 (UES 7881); **Loc. 7**, on *Stenocereus thurberi,* leg. AG & AS, 11-III-2009, obtained from moist chamber, 6-IV-2009 (UES 7890).

Comments—Lizárraga et al. (1999a) published a SEM study of the spore ornamentation. Widely cited for Mexico (Moreno et al. 2007), *D. squamulosum* has been previously cited for Sonora by Moreno et al. (2006) and Lizárraga et al. (2008b).

Didymium sturgisii Hagelst. Figs 18–23

Studied material: **MEXICO. Sonora: Loc. 7**, on *Prosopis glandulosa,* leg. AG & AS, 11-III-2009, obtained from moist chamber, 8-IV-2009 (UES 7884, AH 42978).

Comments—This species is characterized by its dirty white to whitish grey flattened to subglobose fructifications (occasionally with small superficial orifices) and sporocarp interiors with erect pillars or internally traversing trabeculae. Moreno et al. (2001) published an SEM study of the capillitium, pillars, and spores.

Didymium sturgisii has been recorded from Baja California (Moreno et al. 2007), Chihuahua (Salazar-Márquez et al. 2014), Puebla (Estrada-Torres et al. 2009), and Sonora (Esqueda et al. 2012, 2013).

Echinostelium apitectum K.D. Whitney

Studied material: **MEXICO. Sonora: Loc. 1**, on *Prosopis glandulosa* leg. AS & AG, 9-III-2009, observed in moist chamber, 28-III-2009, 4-IV-2009 (UES 7892); **Loc. 3**, on *Stenocereus thurberi*, 19-VIII-2009, obtained in moist chamber, 2-IX-2009, 5-IX-2009 (UES 8589); **Loc. 4**, on *Olneya tesota,* leg. AG & AS, 3-VI-2009, obtained from moist chamber, 17-VI-2009 (UES 8149); **Loc. 5**, on decomposing wood, leg. ML, CS, AS & AG, 18-VIII-2009, obtained in moist chamber, 2-IX-2009, 5-IX-2009 (UES 8581); **Loc. 6**, on *Prosopis glandulosa*, leg. AG & AS, 12-III-2009, observed in moist chamber, 28-III-2009, 2-IV-2009 (UES 7902); **Loc. 7**, on *Prosopis glandulosa*, leg. AG & AS, 22-V-2009, observed in moist chamber, 3-VI-2009, 22-VI-2009 (UES 8151); **Loc. 9,** *Carnegiea gigantea*, leg. ML, CS, AS & AG, 20-VIII-2009, observed in moist chamber, 2-IX-2009, 7-IX-2009 (UES 8584); **Loc. 10**, on *Prosopis glandulosa*, leg. CS, AS & AG, 3-XI-2009, observed in moist chamber, 9-XI-2009, 30-XI-2009 (UES 8703).

Comments—Previously cited from Sonora by Lizárraga et al. (2007, 2008a).

Echinostelium arboreum H.W. Keller & T.E. Brooks

Studied material: **MEXICO. Sonora: Loc. 1**, on decomposing wood**,** leg. AG & AS, 22-V-2009, obtained from moist chamber, 11-VI-2009 (UES 8106 with *Arcyria cinerea*).

Comments—Moreno et al. (2001) published a SEM study of the sporocarp and spores. Previously cited from Sonora by Esqueda et al. (2013), *E. arboreum* has been widely reported from Mexico (Moreno et al. 2007).

Echinostelium colliculosum K.D. Whitney & H.W. Keller

Studied material: **MEXICO. Sonora: Loc. 1**, on *Olneya tesota,* leg. AS & AG, 9-III-2009, 28-III-2009, obtained from moist chamber, 4-IV-2009 (UES 7891); **Loc. 5**, on *Guaiacum coulteri*, 14-III-2009, obtained from moist chamber, 4-IV-2009 (UES 7893); on *Olneya tesota,* observed in moist chamber, 4-IV-2009 (UES 7894); on *Prosopis glandulosa,* obtained from moist chamber, 8-IV-2009 (UES 7895); on *Parkinsonia* sp., leg. AG & AS, 26-V-2009, obtained from moist chamber, 11-VI-2009 (UES 8152); **Loc. 6**, on *Cylindropuntia arbuscula*, leg. AS & AG, 27-V-2009, 3-VI-2009, obtained from moist chamber, 11-VI-2009 (UES 8153); on *Parkinsonia* sp., leg. ML, CS, AS & AG, 19-VIII-2009, in moist chamber, 2-IX-2009, 5-IX-2009 (UES 8588); **Loc. 7**, on *Parkinsonia* sp., leg. AS & AG, 11-III-2009, in moist chamber, 9-IV-2009 (UES 7901); on *Encelia farinosa* A. Gray ex Torr., 22-V-2009, 3-VI-2009, in moist chamber, 11-VI-2009 (UES 8150); on decomposing wood, leg. ML, CS, AS & AG, 17-VIII-2009, in moist chamber, 2-IX-2009, 5-IX-2009 (UES 8591); **Loc. 9**, on *Guaiacum coulteri*, 11-III-2009, 28-III-2009, in moist chamber, 4-IV-2009 (UES 7896); on *Olneya tesota,* in moist chamber, 4-IV-2009 (UES 7898); on *Cylindropuntia arbuscula*, in moist chamber, 4-IV-2009 (UES 7899); leg. ML, CS, AS & AG, 20-VIII-2009, in moist chamber, 2-IX-2009, 7-IX-2009 (UES 8583); **Loc. 10**, on *Cylindropuntia* sp., leg. AS & AG, 12-III-2009, 4-IV-2009 (UES 7900); leg. ML, CS, AS & AG, 18-VIII-2009, in moist chamber, 9-IX-2009 (UES 8582); **Loc. 10**, on *Cylindropuntia* sp., leg. AS & AG, 12-III-2009, 4-IV-2009 (UES 7900).

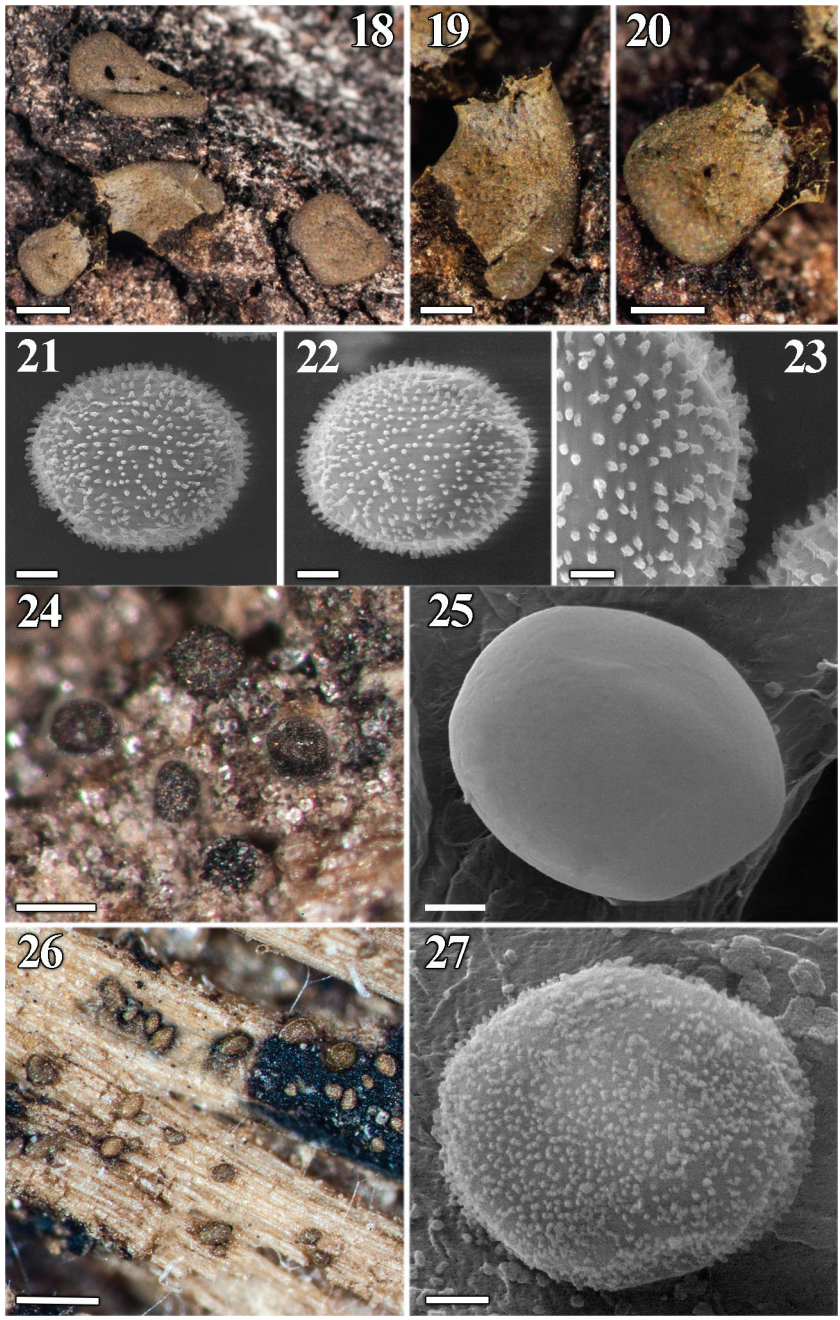
Comments—This species is characterized by its (60–)75–90 µm high stipitate sporocarps, globose 9–13 µm diam. pale yellow spores that have a spine-like ornamentation and articular spore wall. A LM study of sporocarps and spores by Lizárraga et al. (2003) and SEM study by Moreno et al. (2001) have been published.

Echinostelium colliculosum has been recorded for Baja California Sur and Chihuahua (Moreno et al. 2007), Oaxaca and Puebla (Estrada-Torres et al. 2009), and Sonora (Esqueda et al. 2013).

Echinostelium minutum de Bary

Studied material: **MEXICO. Sonora: Loc. 1**, on *Prosopis glandulosa*, leg. ML, CS, AS & AG, 17-VIII-2009, in moist chamber, 2-IX-2009, 7-IX-2009 (UES 8580); **Loc. 3**, on *Stenocereus thurberi*, leg. ML, CS, AS & AG, 17-VIII-2009, 7-IX-2009 (UES 8590); **Loc. 7**, on *Prosopis glandulosa*, leg. AG, 22-05-2009, obtained from moist chamber, 11-06-2009

Figures 18–27. ***Didymium sturgisii*** (AH 42978): 18. Fructifications flattened with some calcium carbonate granules. 19. Sporocarp (detail of small superficial orifices). 20. Capillitium and erect pillars. 21–22. Spores (SEM). 23. Spore ornamentation (detail, SEM). ***Licea denudescens*** (AH 42979): 24. Sporocarps. 25. Spore (SEM). ***Licea succulenticola*** (AH 42980): 26. Sporocarps. 27. Spore (SEM). Bars: 18–19 = 0.5 mm; 20 = 0.25 mm; 21–22 = 2 µm; 23 = 1 µm.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(UES 8154); **Loc. 9**, **on** *Carnegiea gigantea*, 9-IX-2009 (UES 8585); **Loc. 10**, on *Prosopis glandulosa,* leg. CS, AS & AG, 3-XI-2009, in moist chamber, 9-XI-2009, II-2009 (UES 8704).

Comments— Moreno et al. (2001) published a SEM study of the sporocarp and spores. Previously reported from Sonora by Moreno et al. (2006).

Enerthenema papillatum (Pers.) Rostaf.

Studied material: **MEXICO. Sonora: Loc. 4**, on *Forchhammeria watsonii*, leg. ML, CS, AS & AG, 19-VIII-2009, obtained in moist chamber, 5-IX-2009 (UES 8758).

Comments—Lizárraga et al. (1999a) published a SEM study of the spores from collections from Baja California, Mexico. Widely recorded in Mexico (Moreno et al. 2007), *E. papillatus* was recorded previously from Sonora by Moreno et al. (2006).

Fuligo cinerea (Schwein.) Morgan

Studied material: **MEXICO. Sonora: Loc.10**, on sheep manure, leg., AG, 21-V-2009, obtained from moist chamber, 30-VI-20009 (UES 8118).

Comments—Sometimes similar in size as some *Badhamia* species (e.g., *B. spinispors, B. verrucospora* G. Moreno et al.), *Fuligo cinerea* is separated by its ovoid spores covered by small warts that join together to form a reticulum. Cited previously for Sonora by Braun & Keller (1986) and Lizárraga et al. (2007).

Fuligo septica (L.) F.H. Wigg.

Studied material: **MEXICO. Sonora: Loc. 9**, on soil, leg. ML, 11-III-2009 (UES 8677).

Comments—Lizárraga et al. (1999a) published a SEM study of the spores. *Fuligo septica* has a wide distribution in Mexico (Moreno et al. 2007) and has been cited for Sonora by Pérez-Silva et al. (2001) and Lizárraga et al. (2007, 2008a,b).

Licea biforis Morgan

Studied material: **MEXICO. Sonora: Loc. 1**, on *Olneya tesota,* leg. AG & AS, 9-III-2009, obtained in moist chamber, 6-IV-2009 (UES 7905); **Loc. 2**, on *Prosopis glandulosa*, leg. AS & AG, 14-III-2009, obtained in moist chamber, 13-IV-2009 (UES 7908); **Loc. 3,** on *Acacia* sp., 26-V-2009, obtained in moist chamber, 15-VI-2009 (UES 8159); **Loc. 5**, on *Guaiacum coulteri* bark, leg. AS & AG 14-III-2009, obtained in moist chamber, 20-IV-2009 (UES 7913); **Loc. 6**, on *Prosopis glandulosa*, leg. AG & AS, 27-V-2009, obtained in moist chamber, 15-VI-2009 (UES 8162); **Loc. 9**, on *Olneya tesota,* leg. AG & AS, 11-III-2009, obtained in moist chamber, 1-V-2009 (UES 7915); **Loc. 10**, leg. CS, AS & AG, 3-XI-2009, obtained in moist chamber, 12-XII-2009 (UES 8716).

Comments—Lizárraga et al. (1998, 1999b) published SEM studies of the spores. Widely distributed in Mexico (Moreno et al. 2007), *Licea biforis* was previously cited from Sonora by Moreno et al. (2006).

Licea denudescens H.W. Keller & T.E. Brooks Figs 24–25

Fructifications sessile, globose to subglobose, 0.1–0.3 mm diam., 0.1 mm height, brown to blackish. Peridium membranous with some iridescent tones, internally ornamented with small buds. Spores violaceous in mass, yellowish brown by LM, 10–11 µm diam., globose to subglobose, walls thick with pale (thinner) areas, smooth by SEM.

Studied material: **MEXICO. Sonora: Loc. 1**, on *Olneya tesota,* leg. AS & AG, 9-III-2009, obtained in moist chamber, 8-IV-2009 (UES 7916, AH 42979); **Loc. 5**, on *Olneya tesota,* leg. CS, AS & AG, 6-XI-2009, obtained in moist chamber, 12-XII-2009 (UES 8711); **Loc. 7**, on *Parkinsonia* sp., 11-III-2009, obtained in moist chamber, 20-IV-2009 (UES 7918); obtained in moist chamber, 1-V-2009 (UES 7917); **Loc. 8**, on *Acacia greggii* A. Gray, leg. ML, CS, AS & AG, 18-VIII-2009, obtained in moist chamber, 3-X-2009 (UES 8605); **Loc. 9**, on cactus remains, 11-III-2009, observed in moist chamber, 15-IV-2009 (UES 7919).

Comments—*Licea denudescens* is diagnosed by its thick-walled spores with thinner areas and papillae found on the inside of the peridium. It has been cited in Mexico from Puebla (Estrada-Torres et al. 2009), Chihuahua (Salazar-Márquez et al. 2014), and Sonora (Esqueda et al. 2013).

Licea kleistobolus G.W. Martin

Studied material: **MEXICO. Sonora: Loc. 8**, on *Acacia greggii* bark, leg. ML, CS, AS & AG, 18-VIII-2009, observed in moist chamber, 7-IX-2009 (UES 8608).

Comments—Moreno et al. (2001) published a SEM study of *Licea kleistobolus,* which is characterized by its circular to subglobose fructifications with a characteristic operculum and warted spores with groups of denser warts. Cited previously from Sonora by Moreno et al. (2006) and Lizárraga et al. (2007).

Licea succulenticola Mosquera, Lado, Estrada & Beltrán-Tej. Figs 26–27

Fructifications sessile, yellowish to dark-yellow at mature, dispersed to gregarious, subglobose, oval to elongated, 0.1–0.3 mm long, 0.1–0.2 mm diam., and 0.1 mm tall, with an apical and longitudinal dehiscence. Peridium membranous, ornamented on its inner part with small warts. Spores yellow in mass, light yellow by LM, globose to subglobose, (11–)12–14 µm diam., with a lightly paler area, with a slightly warty ornamentation. SEM examination shows that the spore ornamentation is formed by small croziers more or less uniformly distributed over the in spore surface.

Studied material: **MEXICO. Sonora: Loc. 2**, on *Opuntia* sp., 5-XI-2009, observed in moist chamber, 14-XII-2009 (UES 8712); **Loc. 3**, on *Cylindropuntia* sp., leg. AS & AG,

14-III-2009, obtained in moist chamber, 28-III-2009, 20-IV-2009 (UES 7924); obtained in moist chamber, 25-IV-2009 (UES 7925, 7926); **Loc. 4**, on *Lophocereus schottii*, leg. AS & AG, 12-III-2009, obtained from moist chamber, 20-IV-2009 (UES 7923); **Loc. 6**, on *Lophocereus schottii*, leg. CS, AS & AG, 7-XI-2009, observed in moist chamber, 9-XI-2009, 9-XII-2009 (UES 8726); **Loc. 7**, on *Lophocereus schottii,* leg. AS & AG, 11-III-2009, observed in moist chamber, 28-III-2009, 20-IV-2009 (UES 7927); obtained in moist chamber, 1-V-2009 (UES 7928, 7929); on *Stenocereus thurberi*, leg. ML, CS, AS & AG, 17-VIII-2009, observed in moist chamber, 2-IX-2009, 7-IX-2009 (UES 8747, AH 42980); obtained in moist chamber, 14-IX-2009 (UES 8602); obtained in moist chamber, 21-IX-2009 (UES 8604); obtained in moist chamber, 21-IX-2009 (UES 8603); **Loc. 8**, on *Lophocereus schottii*, leg. ML, CS, AS & AG, 18-VIII-2009, observed in moist chamber, 2-IX-2009, 9-IX-2009 (UES 8594); obtained in moist chamber, 14-IX-2009 (UES 8595); obtained in moist chamber, 24-IX-2009 (UES 8596); obtained in moist chamber, 30-IX-2009 (UES 8597); obtained in moist chamber, 5-X-2009 (UES 8598, AH 42981); on *Stenocereus thurberi*, leg. CS, AS & AG, 6-XI-2009, observed in moist chamber, 9 -XI-2009, 14-XII-2009 (UES 8725); **Loc. 10**, on *Cylindropuntia arbuscula*, leg. AG & AS, 12-III-2009, obtained in moist chamber, 20-IV-2009 (UES 7920); on cactus remains, obtained in moist chamber, 20-IV-2009 (UES 7921); obtained in moist chamber, 1-V-2009 (UES 7922); on *Lophocereus schottii,* leg. ML, CS, AS & AG, 18-VIII-2009, obtained in moist chamber, 2-IX-2009, 17-IX-2009 (UES 8599); obtained in moist chamber, 30-IX-2009 (UES 8600); obtained in moist chamber, 30-IX-2009 (UES 8601).

Comments—*Licea succulenticola* resembles *L. pumila* G.W. Martin & R.M. Allen (Martin & Alexopoulos 1969) in sporothecal form and spore colour. (see Mosquera et al. 2003 for differences). Previously recorded from Hidalgo, Morelos, Puebla, and Tlaxcala (Mosquera et al. 2003), Puebla (Estrada-Torres et al. 2009), Sonora (Esqueda et al. 2013), and Chihuahua (Salazar-Márquez et al. 2014).

Paradiacheopsis fimbriata (G. Lister & Cran) Hertel ex Nann.-Bremek. Figs 28–30

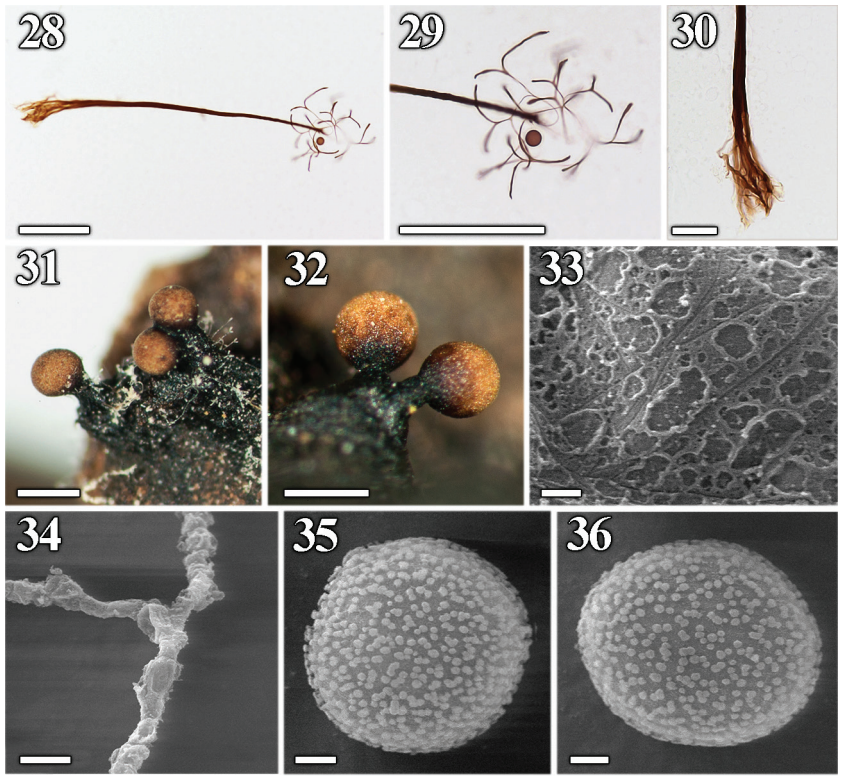
Studied material: **MEXICO. Sonora: Loc. 3**, on *Cylindropuntia* sp., leg. AG, 14-III-2009, observed in moist chamber, 28-III-2009, 13-IV-2009 (UES 7943, AH 42982).

Comments—Widely distributed in Mexico (Moreno et al. 2007), *P. fimbriata* was reported from Sonora by Moreno et al. (2006).

Perichaena depressa Lib.

Studied material: **MEXICO. Sonora: Loc. 1**, on rabbit manure, leg. ML, CS, AS & AG, 17-VIII-2009, obtained in moist chamber, 9-X-2009 (UES 8628); **Loc. 9**, on horse manure, 20-VIII-2009, obtained in moist chamber, 5-X-2009 (UES 8629).

Comments—Lizárraga et al. (1998) and Moreno et al. (2001) published SEM studies of spores and capillitium, comparing type material with samples from Baja California and Sinaloa. Widely distributed throughout Mexico (Moreno et al. 2007), *P. depressa* was previously cited for Sonora by Moreno et al. (2006).



Figures 28–36. ***Paradiacheopsis fimbriata*** (AH 42982): 28. Sporocarp. 29. Sporotheca (detail). 30. Fiber stalk (detail). ***Perichaena stipitata*** (AH 42983): 31–32. Stipitate sporocarp (detail). 33. Peridial inner surface (detail). 34. Capillitium with irregular outline. 35–36. Spores (SEM). Bars: 28–29 = 0.1 mm; 30 = 0.02 mm; 31–32 = 0.5 mm; 33, 35–36 = 1 µm; 34 = 5 µm.

****Perichaena luteola*** (Kowalski) Gilert

Studied material: **MEXICO. Sonora: Loc. 10**, on cow manure, leg. ML, CS, AS & AG, 18-VIII-2009, obtained in moist chamber, 27-IX-2009 (UES 8749); 3-X-2009 (UES 8627).

Comments—The above collections have 10–13 µm diam. globose to subglobose spores that are yellow in mass (lighter yellow by LM) and with a verruculose episporium and a yellow 2–3µm diam. capillitium with smooth surface. Lizárraga et al. (1999b) published a SEM study of material from Baja California. *Perichaena luteola* is widely distributed in Mexico (Moreno et al. 2007).

Perichaena stipitata Lado, Estrada & D. Wrigley Figs 31–36

Fructifications short-stipitate, solitary to gregarious, 0.3–0.8 mm tall. Stipe robust, cylindrical, black, 0.1–0.2 mm long. Sporotheca globose to subglobose, rarely obpyriform, yellow, 0.2–0.5 mm diam. Peridium brownish on the base, inner surface ornamented with small rings by LM and SEM. Hypothallus dark, membranous and irregular. Capillitium sparse, formed by yellowish branched filaments of approximately 2 µm diam., flexible, of irregular outline. Spores yellow in mass, light yellow by LM, 12–15 µm diam., globose, warted. SEM examination shows that the spore is ornamented by warts with smooth apices and which sometimes join into small groups.

Studied material: **MEXICO. Sonora: Loc. 9**, on cactus remains, leg. AG & AS, 26-V-2209, obtained in moist chamber, 30-VI-2009 (UES 8210, AH 42983); on *Lophocereus schottii*, leg. ML, CS, AS & AG, 20-VIII-2009, obtained in moist chamber, 17-IX-2009 (UES 8762); obtained in moist chamber, 24-IX-2009 (UES 8761); obtained in moist chamber, 3-X-2009 (UES 8760, AH 42984); obtained in moist chamber, 9-X-2009 (UES 8643); **Loc. 10**, on *Lophocereus schottii*, leg. ML, CS, AS & AG, 18-VIII-2009, obtained in moist chamber, 5-X-2009 (UES 8642).

Comments—Stipitate fructifications and an inner peridium ornamented by small rings characterize this succulenticolous species. First described as new to science by Estrada-Torres et al. (2009) from Puebla and Queretaro, Mexico, *P. stipitata* was later described from Arizona (USA) by Moreno & Mitchell (2013), who published a colour plate showing its development and morphological characteristics. A new record for Sonora.

Perichaena vermicularis (Schwein.) Rostaf.

Studied material: **MEXICO. Sonora: Loc. 1**, on *Carnegiea gigantea,* leg. CS, AS & AG, 5-XI-2009, obtained in moist chamber, 11-XII-2009 (UES 8734); **Loc. 2**, on *Cylindropuntia arbuscula*, leg. AS & AG, 22-V-2009, obtained in moist chamber, 25-VI-2009 (UES 8191); **Loc. 3**, on *Cylindropuntia* sp., leg. AS & AG 14-III-2009, obtained in moist chamber, 15-IV-2009 (UES 7953); **Loc. 4**, on *Forchhammeria watsonii*, leg. AG & AS, 12-III-2009, obtained in moist chamber, 3-IV-2009 (UES 7944); **Loc. 6**, *Parkinsonia* sp., 19-VIII-2009, obtained in moist chamber, 24-IX-2009 (UES 8633); **Loc. 7**, on *Cactaceae* remains, 11-III-2009, obtained in moist chamber, 8-IV-2009 (UES 7947); obtained in moist chamber, 20-IV-2009 (UES 7948); **Loc. 8**, on *Cactaceae* remains, obtained in moist chamber, 18-VIII-2009, 17-IX-2009 (UES 8631).

Comments—Moreno et al. (2001) published a SEM study of spores and capillitium in collections from Baja California that grew cespitose in moist chamber over different substrates. Widely distributed in Mexico (Moreno et al. 2007), *P. vermicularis* was previously reported from Sonora by Moreno et al. (2006).

Physarum album (Bull.) Chevall.

Studied material: **MEXICO. Sonora: Loc. 7**, on *Prosopis glandulosa,* leg. AG & AS, 17-VIII-2009, obtained in moist chamber, 9-IX-2009 (UES 8651); **Loc. 10**, on *Prosopis glandulosa,* leg. ML, CS, AS & AG, 18-VIII-2009, obtained in moist chamber, 7-IX-2009 (UES 8650).

Comments—Lizárraga et al. (1999b) published a SEM study of spore ornamentation in collections from Baja California. Widely distributed in Mexico (Moreno et al. 2007) and previously reported for Sonora (Lizárraga et al. 2007, 2008b), *Physarum album* frequently grows on many different substrates when cultivated in moist chamber.

Physarum decipiens M.A. Curtis

Fructifications sessile, dispersed to grouped, subglobose or forming short plasmodiocarp. Sporotheca yellow-greenish, 0.3–1.2 × 0.2–0.6 mm, membranous, peridium encrusted with calcium carbonate. Capillitium physaroid. Spores 11–13 μm diam., subglobose to globose, violaceous and slightly warty.

Studied material: **MEXICO. Sonora: Loc. 1**, on *Prosopis glandulosa*, leg. AG & AS, 9-III-2009, obtained in moist chamber, 6-IV-2009 (UES 7967); 22-V-2009, obtained in moist chamber, 11-VI-2009 (UES 8193); **Loc. 2**, on *Prosopis glandulosa*, leg. AS & AG 14-III-2009, obtained in moist chamber, 8-IV-2009 (UES 7970); **Loc. 4**, on *Forchhammeria watsonii*, leg. ML, CS, AS & AG, 19-VIII-2009, obtained in moist chamber, 7-IX-2009 (UES 8649).

Comments—Morphologically, *P. decipiens* is highly variable. Previously cited from Chihuahua (Lizárraga et al. 2003), Oaxaca and Puebla (Estrada-Torres et al. 2009), Tlaxcala (Rodríguez-Palma et al. 2002), and recently Sonora (Esqueda et al. 2012, 2013).

Physarum leucophaeum Fr.

Studied material: **MEXICO. Sonora: Loc. 1**, on *Olneya tesota,* leg. AS & AG, 22-V-2009, obtained in moist chamber, 25-VI-2009 (UES 8194); **Loc. 5**, on *Parkinsonia* sp., leg. AS & AG 14-III-2009, obtained in moist chamber, 1-V-2009 (UES 7966); **Loc. 6**, on *Encelia farinosa*, 27-V-2009, obtained in moist chamber, 22-VI-2009 (UES 8198); **Loc. 8**, on *Larrea tridentata* Coville, leg. AS & AG, 21-V-2009, obtained in moist chamber, 30-VI-2009 (UES 8202); **Loc. 10**, on *Guaiacum coulteri*, leg. ML, CS, AS & AG, 18-VIII-2009, obtained in moist chamber, 9-X-2009 (UES 8653).

Comments— Moreno et al. (2001) published a SEM study of spore ornamentation in collections from Baja California. The recently named species from arid regions of Eurasia and North and South America, *Physarum pseudonotabile* Novozh. et al. (Novozhilov et al. 2013), is very close to *P. notabile*

T. Macbr. and *P. leucophaeum;* distinguishing the three species is complex and additional ecological, morphological, and molecular studies are needed. *Physarum leucophaeum* is widely distributed in Mexico (Moreno et al. 2007), common when cultured in moist chamber. Previously cited from Sonora by Lizárraga et al. (2007, 2008b).

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